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CR 167803

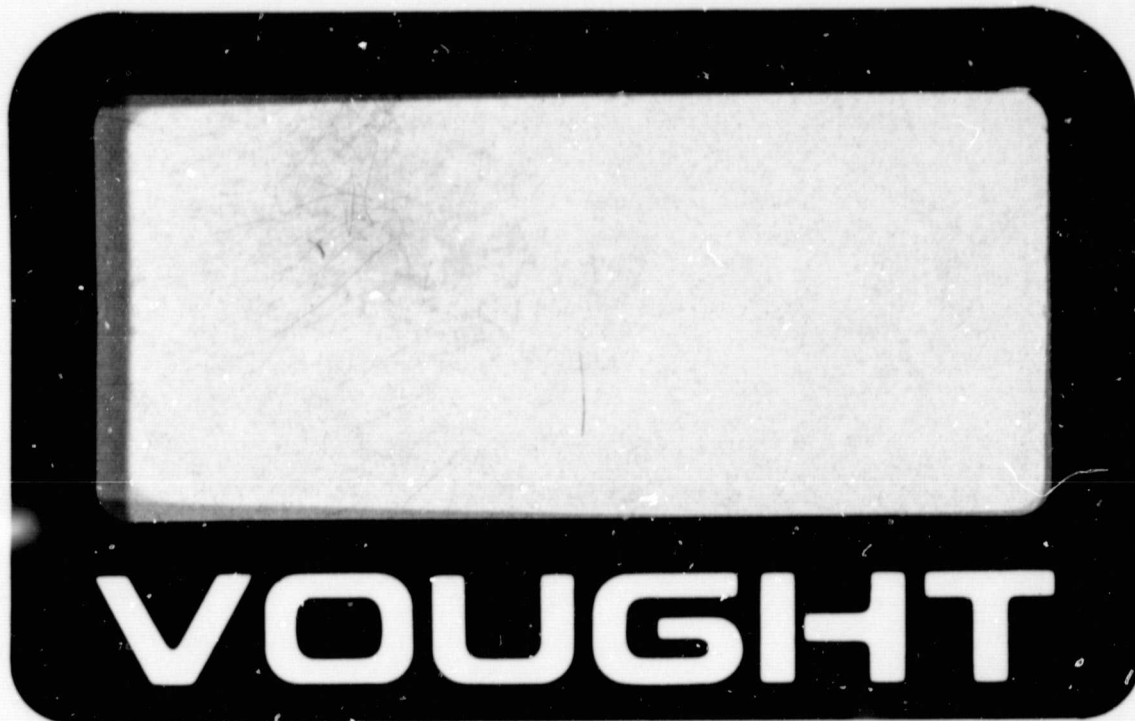
(NASA-CR-167803) NASA SAMELES Final Report  
(Vought Corp., Dallas, Tex.) 57 F  
HC A04/MF A01

N83-19814

CSCL 11D

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NASA SAMPLES FINAL REPORT

CONTRACT NAS9-15685

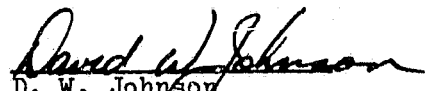
NASA-JSC

VOUGHT REPORT NO. 221RPNC977

3 December 1982

DRD MA-182T, Rev. 1

NASA-Lyndon B. Johnson Space Center  
Houston, Texas 77058

  
D. W. Johnson  
Engineering Project Manager  
LESS Program

VOUGHT CORPORATION  
An LTV Company

M1054B

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# NASA SAMPLES FINAL REPORT

CONTRACT NAS9-15685

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## 1.0 INTRODUCTION

Under the NASA-JSC Contract NAS9-15685 the Vought Corporation was to fabricate Reinforced Carbon-Carbon (RCC) test samples and provide the necessary support to evaluate the results of the oxidation tests performed by NASA-LaRC. In addition, Vought was responsible for the mechanical testing to failure of a maximum of eighteen (18) tension specimens that had been exposed at NASA-LaRC to a combined environment of stress and oxidation simultaneously.

Modification 10C to this contract, effective 31 May 1982, authorized Vought to fabricate additional test specimens of Advanced Carbon Carbon (ACC). This effort is essentially limited to the fabrication and delivery of test specimens to NASA-JSC by 30 April 1983 with no follow-up test support or data evaluation planned.

This report is limited to the contractual items included in the basic contract plus Modifications 1S through 9S plus 11S thereby limiting it to the RCC material. Final reporting on the ACC material included in Modification 10C and 12S will be done separately at the conclusion of the ACC specimen fabrication.

The issuance of this final report satisfies and completes the requirements of Item 2 of this contract as defined in Modification 1S.

## 2.0 CONTRACT HISTORY/TASK DEFINITIONS

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The initiation of the basic contract was accomplished in August 1978 for the fabrication of forty-eight (48) RCC specimens. The eighteen (18) tension specimens were existing at the time, being supplied to NASA-LaRC under a separate contract. The contract modifications are listed below in chronological order with a brief description of the changes. The contract extensions identified below were made to allow completion of the tests at NASA-LaRC.

CONTRACT NAS9-15685      1 September 1978

- o Fixed Price Contract      \$55,000
- o Exhibit A Statement of Work
  - Fabrication of forty-eight (48), thirty-eight (38) ply mechanical property specimens 17.0 centimeters x 4.3 centimeters (6.7 inches x 1.7 inches)
  - Performance of tension failing load tests on a maximum of eighteen (18) specimens
- o Completion date      31 January 1979

MODIFICATION 1S      8 January 1979

- o Contract extension to 30 April 1979

MODIFICATION 2S      1 May 1979

- o Contract extension to 31 October 1979

MODIFICATION 3S      16 November 1979

- o Contract value increased to \$75,525
- o Exhibit B Statement of Work
  - Additional requirements for forty-eight (48), 7.1 centimeters (2.8 inch) diameter plasma arc test specimens to be fabricated from nineteen (19) ply material
- o Contract extension to 31 October 1980

MODIFICATION 4S      12 December 1979

- o Contract extension to 1 July 1980

MODIFICATION 5S

29 July 1980

- o Contract extension to 29 July 1980

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MODIFICATION 6S

31 October 1980

- o Contract extension to 1 June 1981

MODIFICATION 7S

8 December 1980

- o Delivery addresses changed for reports

MODIFICATION 8S

31 May 1981

- o Contract extension to 15 January 1982

MODIFICATION 9S

15 January 1981

- o Contract extension to 1 July 1982

MODIFICATION 10C

31 May 1982

- o Exhibit C
  - Additional requirements to fabricate eight (8),  
30.5 centimeters x 30.5 centimeters (12 inch x 12 inch)  
ACC panels to be cut into test specimens

MODIFICATION 11S

1 July 1982

- o Contract extension to 1 October 1982

MODIFICATION 12S

1 June 1982

- o Contract value increased by \$49,140 for ACC panels

### 3.0 DISCUSSION

The forty-eight (48) test specimens identified in Exhibit A of the contract were fabricated from three existing panels transferred from a Rockwell contract Purchase Order M8J3XMS-483150D that had been previously terminated. Two of these panels (HP110 and HP113) were at the RCC-2 stage in the process cycle and the other one (HP116) was in the as-cured condition. Vought Engineering Release (ER) S1001.327 was issued to resume processing of these panels through machining, coating, and TEOS impregnation. These specimens were shipped to NASA-JSC on 15 January 1979, reference RFS-RCC-153

included in Enclosure (1). The specimen identification list and the documentation package for these specimens is also included in Enclosure (1). Eighteen (18) of these specimens were eventually returned to Vought for Type A coating. This was accomplished and the specimens shipped to NASA-LaRC on 7 January 1980 on RFS-RCC-193, a copy of which is included in Enclosure (1) along with a list of the specimens involved.

The combined environment test specimens were sent to Vought from NASA-LaRC and machined to the tension test configuration per ER S1001.363 in July 1979. The tension tests were performed in the Vought Structures Test Lab in August 1979 according to the requirements of Test Request 221TQ00789, a copy of which is included in Enclosure (2). The results of the tension tests are documented in Vought Design Information Release (DIR) 2-30400/RCC/9-0017 which is also included in Enclosure (2).

The minimum of twenty-seven (27) and maximum of forty-eight (48) plasma arc discs added to the contractual requirements by Modification 3S were started in fabrication in December 1979. Three panels (A306, A307, and A308) were fabricated per the instruction of ER S1001.377 through machining, Silicon Carbide Coating, and TEOS impregnation. Half of these specimens were coated with the Type A enhancement process. Thirty-eight (38) of these specimens, twenty (20) with Type A, were shipped to NASA-JSC on 27 June 1980 on RFS-RCC-210, a copy of which is included in Enclosure (3). The specimen identification and the certificate of compliance is also included in Enclosure (3). The remainder, a total of ten (10) specimens, were transferred to NASA-ARC under Purchase Order 71125B (LAM). These specimens were shipped to NASA-ARC on 4 August 1980 on RFS-RCC-218, a copy of which is included in Enclosure (3).

The radiant mass loss tests on the original set of RCC specimens were concluded at NASA-LaRC and the data sent to Vought in October 1982. This data has been documented and comparisons made with the previous February 1978 mass loss/mission life correlation in DIR 2-53200/RCC/2-0008. A copy of this document is included in Enclosure (4).



#### 4.0 CONCLUSIONS/RECOMMENDATIONS

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The results of the combined environment tests and the radiant mass loss tests at NASA-LaRC were compatible with similar tests performed on RCC by other test agencies. The complex combined environment tests gave the same results as the simpler cyclic tests performed elsewhere. Also the radiant mass loss tests on both TEOS only and Type A coated specimens agreed with previous test data.

This report concludes the requirements of this contract on RCC Samples. There are no additional test data needed to supplement the current RCC data at this time. Future effort should be directed toward the next generation carbon material, ACC.

ENCLOSURE 1

CONTENTS:

- o REQUEST FOR SHIPMENT RFS-RCC-153
- o REQUEST FOR SHIPMENT RFS-RCC-193
- o QUALITY DOCUMENTATION PACKAGE

☐ TOP SECRET, ☐ CONFIDENTIAL  
☐ SECRET ☒ UN-CLASSIFIED  
☐ CONFIDENTIAL - MODIFIED HANDLING  
CHECK ONE

Vought Corporation  
P.O. Box 225907  
Dallas, Texas 75265

☒ SHIPPING REQUEST  
☐ SHIPPING MEMO  
☐ DEBIT MEMO

Transportation Office  
Building 420  
NASA Lyndon B. Johnson Space Ctr  
Houston, Texas 77058

DATE 1 - 15 - 79

NUMBER RFS-RCC-153

YOUR INVOICE	DATED	AMOUNT	REC. REPORT

Mark For:  
Accountable Property Officer 807402  
Purchase Request No. 8-122-020  
Contract No. NAS9-15685  
For Reissue To:  
Don J. Tilliam ES3 13 208

☐ RETURNED FOR CREDIT  
☐ RETURNED FOR CREDIT AND REPLACEMENT  
☐ REPAIR OR REWORK AT VENDOR'S EXPENSE  
☐ REPAIR OR REWORK AT OUR EXPENSE  
☐ REPAIR OR REPLACEMENT COVERED BY GUARANTEE  
☒ MISCELLANEOUS (EXPLAIN) Test Specimens

CHARGE  
TO

(None -

INSPECTION REQUIRED: ☐ LTV ☐ GOV'T. ☐ CUST. see note) MATERIAL CLASS: ☐ HAZARDOUS ☒ NON-HAZARDOUS

REFER TO: Contract NAS9-15685 Articles IV, V, VI and VII	ACCOUNT NO.	DELIVERY DATE DUE ASAP	YOUR PO NUMBER
F. O. B. NASA-JSC	VIA Freight	B/L NO.	PREPAID TERMS COLLECT
REF. REPORT NO.	OUR PO NUMBER	STORES REQ.	GOV'T CONTRACT NAS9-15685
			ORDER NO. 3804-EAEE

CONTRACT ITEM NO.	QUANTITY	PART NO.	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
1	148	-	RCC Test Samples, Serial #	\$49,000.00	\$49,000.00
			13 HP 22 16 HP 06 248-D1		
			13 HP 23 16 HP 07 248-D2		
			13 HP 24 16 HP 08 248-D3		
			13 HP 25 16 HP 09		
			13 HP 27 16 HP 10 16 HP 11		
			13 HP 28 16 HP 12		
			13 HP 30 10 HP 18 16 HP 13		
			13 HP 31 10 HP 19 16 HP 14		
			13 HP 34 10 HP 21 16 HP 15		
			13 HP 35 10 HP 22 16 HP 16		
			10 HP 24 16 HP 17		
			027-D1 10 HP 25 16 HP 18		
			027-D2 10 HP 27 16 HP 19		
			027-D3 10 HP 28 16 HP 20		
			10 HP 29		
			16 HP 01 10 HP 33		
			16 HP 02 10 HP 35		
			16 HP 03 10 HP 36		
			16 HP 04		
			16 HP 05		

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INSPECTION		LAYOUT		PRESERVATION		PACKING		AUTHORIZED IN ACCORDANCE WITH APR 13 1979	
LTV	CUST	LTV	CUST	LTV	CUST	LTV	CUST	SIGNATURE	
								G. B. Whisenant 2-04003 10/75	
BOX NO.		TYPE		LGTH	WIDTH	HT.	GROSS WT.	NAME (TYPE) UNIT EXT.	
								FOR SHIPPING USE ONLY	
CHECK		M.I.R.R.		COMM. INV.		SHIP. MEMO		DATE SHIPPED	

REQUEST FOR SHIPMENT

0-87574 R2

SECURITY CLASSIFICATION  
☐ TOP SECRET ☐ CONFIDENTIAL  
☐ SECRET ☒ UNCLASSIFIED  
☐ CONFIDENTIAL - MODIFIED HANDLING  
 CHECK ONE

Vought Corporation  
 Page 2

Page 2 of 2

☒ SHIPPING REQUEST  
☐ SHIPPING MEMO  
☐ DEBIT MEMO

Transportation Officer

DATE 1 - 15 - 79

NUMBER RFS-RCC-153

YOUR INVOICE	DATED	AMOUNT	REG. REPORT

CHARGE  
 TO

- ☐ RETURNED FOR CREDIT  
☐ RETURNED FOR CREDIT AND REPLACEMENT  
☐ REPAIR OR REWORK AT VENDOR'S EXPENSE  
☐ REPAIR OR REWORK AT OUR EXPENSE  
☐ REPAIR OR REPLACEMENT COVERED BY GUARANTEE  
☒ MISCELLANEOUS (EXPLAIN)

(None)

INSPECTION REQUIRED: ☐ LTV ☐ GOV'T. ☐ CUST. See Note: MATERIAL CLASS: ☐ HAZARDOUS ☒ NON-HAZARDOUS

REFER TO: Contract NAS9-15685		ACCOUNT NO.	DELIVERY DATE DUE ASAP		YOUR PO NUMBER
Articles IV, V, VI and VII					
F. O. D. NASA-JSC		VIA Freight	B. L. NO.	PREPAID COLLECT	TERMS
REG. REPORT NO.	OUR PO NUMBER	STAGES REQ.	GOV'T CONTRACT NAS9-15685	ORDER NO.	G. O. NUMBER 3804-EAEE

CONTRACT ITEM NO.	QUANTITY	PART NO.	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
2	1	-	Data Package	-	-
NOTE: Ship by Form DD 250. Final Inspection and acceptance will be accomplished by the contracting officer at NASA/LBJ Space Center. See below for additional distribution of DD 250.					
2 copies Norman Lamb, Mail Code BC72(3) R & T Procurement Branch					
2 copies Transportation Officer Building 420					
1 copy Don J. Tillian, Mail Code ES3					
1 copy JSC Accountable Property Officer, Mail Code JF9					
1 copy JSC Cost and Property Accounting Branch, Mail Code BR 5					
NASA Lyndon B. Johnson Space Center Houston, TX					

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INSPECTION		LAYOUT		PRESERVATION		PACKING		AUT. AUTHORIZED IN ACCORDANCE WITH AER, S.P. 441,1	
LTV	CUST	LTV	CUST	LTV	CUST	LTV	CUST	SIGNATURE G. B. Whisenhunt 2-24-80 3475	
BOX NO.		TYPE		LGTH	WIDTH	HT.	GROSS WT.	NAME (TYPE) DATE	
								FOR SHIPPING USE ONLY	
CHECK		M.I.R.R.		COMM. INV.		SHIP. MEMO		DATE SHIPPED	

REQUEST FOR SHIPMENT

## SECURITY CLASSIFICATION

☐ TOP SECRET ☐ CONFIDENTIAL  
☐ SECRET ☒ UN-CLASSIFIED  
☐ CONFIDENTIAL - MODIFIED HANDLING

CHECK ONE

(TYPE IN DIVISION NAME)

Vought Corporation  
P. O. Box 225907  
Dallas, Texas 75222

☒ SHIPPING REQUEST  
☐ SHIPPING MEMO  
☐ DEBIT MEMO

SHIP TO

National Aeronautics & Space Admin.  
Langley Research Center  
Hampton, Virginia 23665

DATE 1-7-80

NUMBER RCC-193

YOUR INVOICE	DATED	AMOUNT	REC. REPORT

CHARGE TO

Attn:  
Dr. Don Rummel  
Mail Stop 180B

☐ RETURNED FOR CREDIT  
☐ RETURNED FOR CREDIT AND REPLACEMENT  
☐ REPAIR OR REWORK AT VENDOR'S EXPENSE  
☐ REPAIR OR REWORK AT OUR EXPENSE  
☐ REPAIR OR REPLACEMENT COVERED BY GUARANTEE  
☒ MISCELLANEOUS (EXPLAIN) Return NASA Specimens.

INSPECTION REQUIRED: ☐ LTV ☐ GOV'T. ☐ CUST. ☒ None MATERIAL CLASS: ☐ HAZARDOUS ☒ NON-HAZARDOUS

REFER TO:	ACCOUNT NO.	DELIVERY DATE DUE	YOUR PO NUMBER
F. O. B.	VIA Federal Express	B/L NO. <input checked="" type="checkbox"/> PREPAID <input type="checkbox"/> COLLECT	TERMS
REF. REPORT NO.	OUR PO NUMBER	STORES REQ.	GOV'T CONTRACT NAS9-15685
			ORDER NO.
			G. O. NUMBER 3804 EAE

CONTRACT ITEM NO.	QUANTITY	PART NO.	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
1	18	-	RCC Test Samples with Type A Coating, Serial #'s 10HP22 10HP24 10HP27 10HP33 10HP35 13HP22 13HP23 13HP25 13HP27 13HP31 13HP34 16HP01 16HP04 16HP10 16HP13 16HP14 16HP15 16HP20		

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INSPECTION		LAYOUT		PRESERVATION		PACKING		AUTHORIZED IN ACCORDANCE WITH FED. R.P. 441.1			
LTV	CUST	LTV	CUST	LTV	CUST	LTV	CUST	SIGNATURE G. B. Whisenhunt			
X NO.		TYPE	LGTH	WIDTH	HT.	GROSS WT.		NAME (TYPE) UNIT EXT. 2-18300 3475			
								FOR SHIPPING USE ONLY			
CHECK	M.I.R.R.	COMM. INV.	SHIP. MEMO	DATE SHIPPED							

REQUEST FOR SHIPMENT

0-87574 R2

NASA TEST SPECIMENS  
DOCUMENTATION PACKAGE  
CONTRACT NAS9-15685

VOUGHT CORPORATION

P O BOX 225907

DALLAS, TEXAS 75265

This certifies that RCC test specimens listed herein conform to the requirements of Contract NAS9-15685 with the exceptions noted in the Deviation Summary.

Test reports and acceptance data are on file and are subject to examination on request.



F. J. Patterson  
Quality Program Manager  
Leading Edge Structural  
Subsystem

23 Jan 1978

DATE

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## TABLE OF CONTENTS

### PAGE

1	Certification of Compliance
2	Table of Contents
3	Statement of Nondestructive Test Results.
4	Test Data Summary
5	Deviation Summary
6	Serial Number Listing



### NONDESTRUCTIVE TESTS RESULTS

RCC specimens included in this shipment have been subjected to radiographic examination and ultrasonic inspection per Process Specification 208-7-40, 208-7-41 and 208-7-42 and accepted.

Coating thickness has been verified by Eddy Current technique and has been accepted with deviations noted in Deviation Summary.

TEST DATA SUMMARY

FLEXURE TEST

	<u>ACTUAL</u>	<u>REQUIRED</u>
HP 110 As coated.	17,755	14,700
Thermally conditioned	15,794	14,700
HP 113 As Coated	16,471	13,700
Thermally conditioned	16,279	13,570
HP 116 As coated	15,894	14,700
Thermally conditioned	15,448	13,110

MASS LOSS (Tube Furnace Test)

HP 110	.0002 lb/ft <sup>2</sup>	.041 lb/ft <sup>2</sup>
HP 113	.0012	
HP 116	.0050	

DEVIATION SUMMARY

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- 1- Specimens listed have coating thickness below minimum required by 208-7-41 and drawing requirements:

<u>Specimen S/N</u>	<u>Bag Side Thickness</u>	<u>Mold Side Thickness</u>
13HP 22	.019	.020
23	.019	.020
24	.018	.020
25	.018	.019
27	.019	.020
28	.018	.020
30	.018	.019
31	.017	.018
<del>34</del>	.018	.020
35	.018	.020
10HP 18	.017	.020
19	.017	.020
21	.017	.022
22	.018	.020
24	.017	.020
25	.017	.019
27	.018	.020
28	.017	.019
29	.017	.020
33	.018	.020
35	.018	.021
36	.018	.020
027 D3	.019	.024
248 D2	.019	.023

Thicknesses shown are minimums recorded on each side of the specimen.

Reference MRAs 79570, 79571, 79598.

- 2- The following specimens have minor chips in coating a edges:

16HP 04, 10, 13, 14, 15 and 16. Ref DS 92988.

SERIAL NUMBER LISTING

13HP 22  
23  
24  
25  
27  
28  
30  
31  
34  
35

10HP 18  
19  
21  
22  
24  
25  
27  
28  
29  
33  
35  
36

027-D1  
D2  
D3

248-D1  
D2  
D3

16HP 01  
02  
03  
04  
05  
06  
07  
08  
09  
10

16HP 11  
12  
13  
14  
15  
16  
17  
18  
19  
20

ENCLOSURE 2

CONTENTS:

- o TEST REQUEST 221TQ00789
- o DESIGN INFORMATION RELEASE 2-30400/RCC/9-0017

## ENGINEERING TEST LABORATORY TEST REQUEST o 36782

Page 1 of 3

TITLE Tensile Strength Static Test of LaRC Exposed		DATE 7-18-79		CHARGE NO. 3804 EAE 1001	
RCC Specimens		MODEL LESS		REQ. BY C. W. Payne	
		DATE DATA REQ.		GROUP 2-30400	
				MANHOURS	
				EST.	
				ACTUAL	
PROJECT TEST ENGINEER		APPROVAL ORIG. GRP. <i>E. O. Scott 7/18/79</i>		WITNESSES	
UNIT ASSIGNMENT		PROJECT <i>D. W. Johnson 19 July 79</i>		YES NO	
LAB. OR DEPT. RESP. FOR TEST		LABORATORY		CUSTOMER	
				COMPANY	
REFERENCE				TOTAL	

by

N. H. Godbold, D. W. Johnson, R. O. Scott, M. Green, G. B. Whisenhunt, C. N. Webster

Dr. D. R. Rummier (LaRC), D. J. Tillian (NASA-JSC)

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REVISION NOTICE AND SIGNATURES	DATE RELEASED	REVISION SCOPE

## 1.0 PURPOSE

The purpose of the tests is to obtain the tensile strength of RCC material specimens that have been exposed to the combined environments of temperature, pressure and stress by LaRC.

## 2.0 DESCRIPTION OF SPECIMENS

Specimens will be fabricated by Manufacturing per the requirements of ER No. S1001.363. Test type, specimen identification and machine details are shown in Table 1.

## 3.0 TEST PROCEDURES AND DATA REQUIREMENTS

The test procedures and data requirements are the same as those outlined in the design allowables test requests shown in Table 1.

Flatness of each specimen is to be checked and any curvature of specimen is to be measured and recorded.

## 4.0 TEST SCHEDULE AND WITNESS

Test specimens will be supplied to the test laboratory by 1 August 1979. Tests will be performed on 7 August 1979. The test date is to agree with the date that Dr. D. R. Rummler from LaRC will be at Vought.

Tests will be witnessed by C. W. Payne, (Ext. 2149) and Dr. D. R. Rummler.

TABLE 1

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TEST TYPE	SPECIMEN ID.	MACHINE DETAIL	TEST REQUEST REFERENCE
<p>TENSION</p> <p>↑</p> <p>↓</p> <p>TENSION</p>	<p>NO. 39-1</p> <p>↑</p> <p>-2</p> <p>-3</p> <p>-4</p> <p>-5</p> <p>-6</p> <p>-7</p> <p>↓</p> <p>NO. 39-8</p> <p>No. 40-1</p> <p>↑</p> <p>-3</p> <p>-4</p> <p>-5</p> <p>-6</p> <p>-7</p> <p>-8</p> <p>↓</p> <p>No. 40-9</p>	<p>DWG. 221GT6016</p> <p>DETAIL D</p> <p>↑</p> <p>↓</p> <p>DWG. 221GT6016</p> <p>DETAIL D</p>	<p>{221TQ00233</p> <p>TR74-59900-009</p> <p>↑</p> <p>↓</p> <p>{221TQ00233</p> <p>TR74-59900-009</p>



DESIGN INFORMATION ~~REQUEST~~ - RELEASE 0-82042 R3

MODEL(S) AND KFF.

Tensile Strength Static Test of LaRC

DIR. NO.

2-30400/RCC/9-0017

REV.

WBS OR DO NUMBER

Exposed RCC Specimens

SYSTEM

REF. G.O. NUMBER

DATE

PAGE

OF

LESS

3804 EAEE 1001

14 August 1979

1

6

FILL IN BLOCK BELOW FOR INFORMATION REQUEST

FILL IN BLOCK BELOW FOR INFORMATION RELEASE

TO

GROUP

IN REPLY TO DIR. NUMBER

REQ. BY

GROUP

REL. TO

GROUP

D. W. Johnson

2-51500

REASON:

PREPARED BY

DATE

CHECKED BY

DATE

C. W. Payne

14 Aug '79

C. W. Payne

14 Aug '79

☐ VAC ONLY

☐ NASC

☐ NPRO

☐

GROUP APP

DATE

PROJ OFFICE

DATE

R. A. Scott

8/15/79

D. W. Johnson

16 Aug '79

CC

G. B. Whisenhunt, M. Green, C. N. Webster, N. H. Godbold, Dr. D. R. Rummel (LaRC),

D. J. Tillian (NASA-JSC), H. L. Spence

REFERENCES:

- (a) Vought Corporation Test Request No. 221TQ00789, "Tensile Strength Static Test of LaRC Exposed RCC Specimens", dated 18 July 1979.
- (b) Vought Corporation Test Information Release TIR 79-59900-135 dated 14 August 1979.
- (c) Vought Corporation Report No. 221RP00614, "Leading Edge Structural Subsystem Mechanical Design Allowables for Material with Improved Coating System", dated 15 July 1977.

Revision Notice and Signatures	Date Released	Revision Scope

## INTRODUCTION

Sixteen RCC tension specimens were loaded to failure on 7 and 8 August 1979. Testing was conducted at the Vought Corporation Structures and Systems Laboratories according to the instructions of Reference (a). Test specimens consisted of eight each of 19 ply and 33 ply material. Prior to the static tension failing load test the specimens were subjected to a combined temperature and pressure environment. One half of the specimens of each thickness were subjected to tensile stress in combination with the temperature and pressure environment. The 19 ply specimens were exposed to a high temperature profile with maximum temperature of 2480°F. The 33 ply specimens were exposed to a temperature profile with maximum temperature of 1115°F. The combined exposure tests for all specimens were conducted at Langley Research Center (LaRC).

## DISCUSSION

After completion of the combined environment tests the specimens were delivered to Vought Corporation and final machined to the test configuration. A sketch of the specimen is shown in Figure I. Some of the 19 ply specimens were not completely flat with the maximum bow being .025 inches for specimen 39-6. While testing specimens 39-1, 39-2 and 39-3 it was discovered that the specimens were not seating properly in the loading blocks. The remaining specimens were returned to the machine shop and the radius reworked to improve the mating of the specimens to the loading blocks. Failure of all the specimens, except one, was similar in nature to failure of previously tested RCC tension specimens. Specimen 40-4 did not fail in tension in the straight section. Failure occurred as cracking of the coating and interlaminar shear of the substrate in the region of a loading block. As the failed specimens were returned to Dr. D. R. Rummier (LaRC) immediately after completion of the tests, very limited post test examination of the specimens were performed by Vought.

## SUMMARY

Specimen identification, total coating thickness, mass loss and tension tests results are presented in Table I. The design allowables developed for RCC material used on the Space Shuttle Orbiter Wing Leading Edge and Nose Cap are normalized for a material coating thickness of 0.06 inches, total both sides.

In order to make a comparison of the test results and the LESS RCC design allowables, the test data tension strength of Table I was adjusted for a total coating thickness of 0.06 inches. Plots of the adjusted test values and LESS RCC design allowable "A" values are shown in Figure II. The design allowable "A" value represents a minimum guaranteed value having 99 percent probability and 95 percent confidence. As shown in Figure II no test specimen failed at a tension stress below the design allowable "A" value.

TABLE I  
TENSION SPECIMEN TEST DATA -

SPECIMEN ID	NO. PLIES	TOTAL COATING THICKNESS IN.	MASS LOSS LBS/FT <sup>2</sup>	LOADED ①	TEST FAILING LOAD ③ LBS.	TENSION STRENGTH PSI		MODULUS E <sub>t</sub> ③ X10 <sup>6</sup> PSI
						TEST DATA F <sub>tu</sub> ③	ADJUSTED DATA F <sub>tu</sub> ④	
39-1	19	.0434	.0062	NO	963	8464	7194	1.34
39-2	19	.0450	.00619	YES	893	7873	6770	1.54
39-3	19	.0464	.01478	YES	760	6652	5787	1.13
39-4	19	.0476	.00683	YES	893	7820	6882	1.43
39-5	19	.0476	.01213	NO	835	7331	6451	1.41
39-6	19	.0476	.0062	NO	862	7588	6677	1.09
39-7	19	.0474	.01216	YES	735	6459	5652	1.24
39-8	19	.0482	.01157	NO	805	7086	6243	1.07
40-1	33	.0494	.10058	NO	1040	5259	4686	1.14
40-3	33	.0496	.07308	YES	1319	6704	5000	0.98
40-4	33	.0508	.1037	NO	912	②	②	0.95
40-5	33	.0488	.06114	NO	1380	6975	6208	0.99
40-6	33	.0492	.0546	YES	1350	6911	6158	1.60
40-7	33	.0484	.0467	NO	1422	7186	6360	1.42
40-8	33	.0506	.0740	YES	1107	5651	5114	1.25
40-9	33	.0500	.09294	YES	1120	5648	5083	1.31

- ① Tension load applied during thermal exposure.  
 ② Specimen did not fail in tension. Failure occurred as cracking of the coating and interlaminar shear of the substrate in the region of a loading block.  
 ③ From Ref. (b).  
 ④ The adjusted strengths reflect normalized data for 0.06 inch nominal total coating thickness.

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FIGURE I  
SPECIMEN GEOMETRY

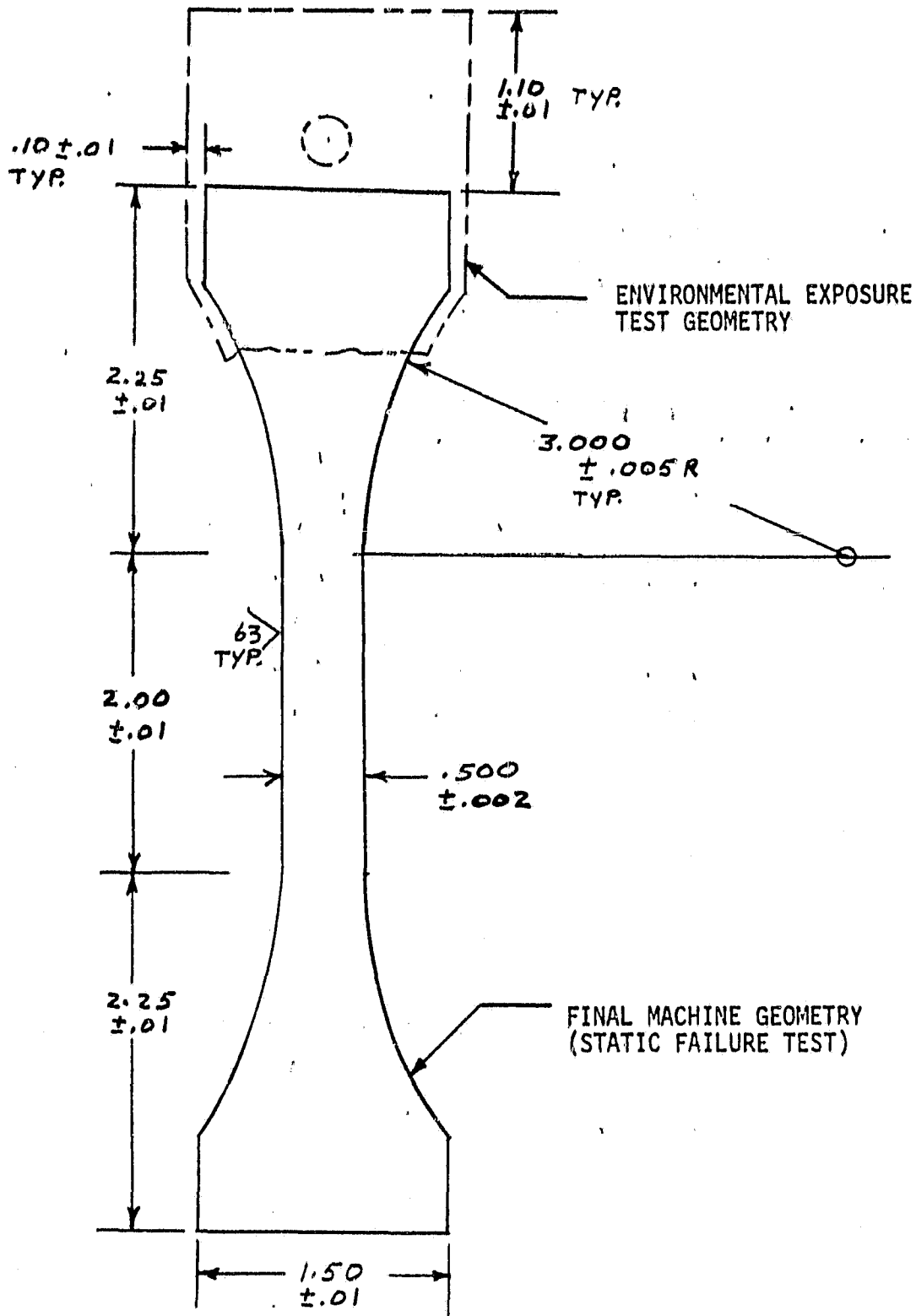
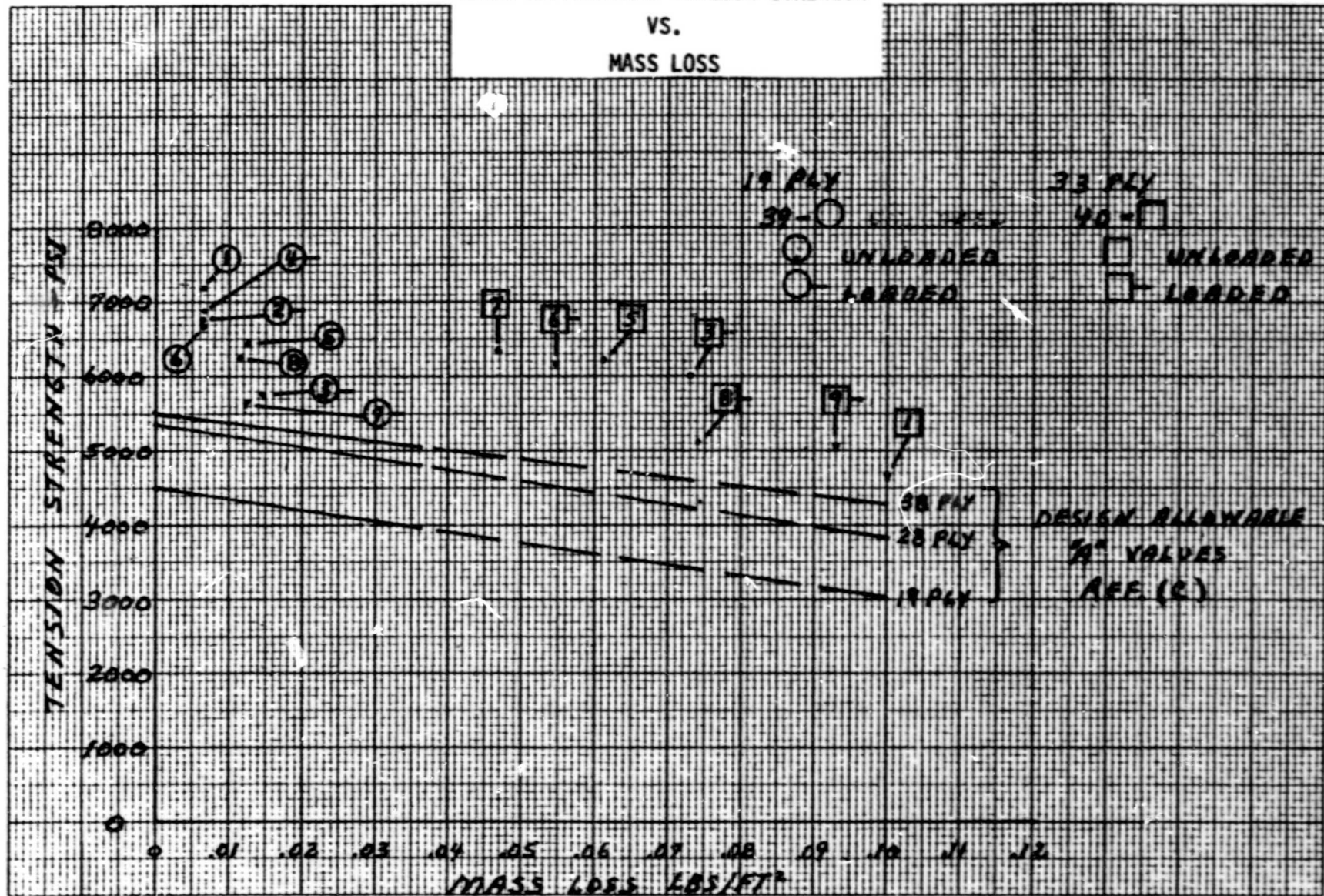


FIGURE II

ROOM TEMPERATURE TENSION STRENGTH  
VS.  
MASS LOSS



ENCLOSURE 3

CONTENTS:

- o REQUEST FOR SHIPMENT RFS-RCC-210
- o QUALITY DOCUMENTATION PACKAGE
- o REQUEST FOR SHIPMENT RFS-RCC-218

SECURITY CLASSIFICATION  
☐ TOP SECRET ☐ CONFIDENTIAL  
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Vought Corporation  
P. O. Box 225907  
Dallas, Texas 75265

☒ SHIPPING REQUEST  
☐ SHIPPING MEMO  
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SHIP  
TO

Transportation Office  
Bldg. 420  
NASA/Lyndon B. Johnson Space Center  
Houston, Texas 77058

DATE 6-27-80

NUMBER RFS-RCC-210

YOUR INVOICE	DATED	AMOUNT	REC. REPORT

CHARGE  
TO

Mark for:  
Accountable Property Officer 807402  
Purchase Request No. 8-122-020  
Contract No. NAS9-15685

☐ RETURNED FOR CREDIT  
☐ RETURNED FOR CREDIT AND REPLACEMENT  
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☐ REPAIR OR REWORK AT OUR EXPENSE  
☐ REPAIR OR REPLACEMENT COVERED BY GUARANTEE  
☒ MISCELLANEOUS (EXPLAIN) Contract Deliveries

For Reissue to:  
Don J. Tillian/ES3 13 208

INSPECTION REQUIRED: ☐ LTV ☐ GOV'T. ☐ CUST. (None- See Note) MATERIAL CLASS: ☐ HAZARDOUS ☒ NON-HAZARDOUS

REFER TO: Contract NAS9-15685	ACCOUNT NO.	DELIVERY DATE DUE	YOUR PO NUMBER
Articles IV, V, VI & VII		7-18-80	
F.O.B.	VIA	B/L NO.	TERMS
NASA/JSC	Fed. Express Priority I		F. P.
REF. REPORT NO.	OUR PO NUMBER	GOV'T CONTRACT	ORDER NO.
		NAS9-15685	
			G. O. NUMBER
			3804-EAEE-6002

CONTRACT ITEM NO.	QUANTITY	PART NO.	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
3.1	20	-	RCC Test Samples, with Type A Coating Enhancement, Serial #'s: A306-9 thru A306-14 A307-1 thru A307-7 A308-9 thru A308-15		
3.2	18	-	RCC Test Samples with TEOS, Serial #'s: A306-1 thru A306-6 A307-9 thru A307-14 A308-1 thru A308-6		\$20,525
3.3	1	-	Quality Control Logbooks		

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INSPECTION		LAYOUT		PRESERVATION		PACKING		AUTHORIZED IN ACCORDANCE WITH AER. S.P. 441.1			
LTV	CUST	LTV	CUST	LTV	CUST	LTV	CUST	SIGNATURE			
								G. B. Whisenhunt 2-19200 7475			
BOX NO.		TYPE		LGTH	WIDTH	HT.	GROSS WT.	NAME (TYPE) UNIT EXT.			
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Transportation Office

DATE 6-27-80

NUMBER RFS-RCC-210

YOUR INVOICE	DATED	AMOUNT	REC. REPORT

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ARGE

SPECTION REQUIRED ☐ LTV ☐ GOV'T. ☐ CUST.

MATERIAL CLASS: ☐ HAZARDOUS ☐ NON-HAZARDOUS

PER TO:		ACCOUNT NO.	DELIVERY DATE DUE		YOUR PO NUMBER	
O. B.		VIA	B/L NO.	PREPAID COLLECT	TERMS	
J. REPORT NO.	OUR PO NUMBER	STORES REQ.	GOV'T CONTRACT	ORDER NO.	G. O. NUMBER	
TRACT TEM NO.	QUANTITY	PART NO.	DESCRIPTION		UNIT PRICE	TOTAL AMOUNT

NOTE: Ship by Form DD250. Final Inspection and Acceptance will be accomplished by the Contracting Officer at NASA/JSC. See below for additional distribution of DD250:

2 Copies	NASA/Lyndon B. Johnson Space Center R & T Procurement Branch Attn: Virginia Thompson/BC72 (9) Houston, Texas 77058
2 Copies	Transportation Officer Bldg. 420
1 Copy	Don J. Tillian, Mail Code ES3
1 Copy	JSC Accountable Property Officer Mail Code JF9
1 Copy	JSC Cost and Property Accounting Branch Mail Code BR5

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INSPECTION		LAYOUT		PRESERVATION		PACKING		AUTHORIZED IN ACCORDANCE WITH AER, S.P. 441.1			
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QUALITY DOCUMENTATION PACKAGE

NASA 9-15685

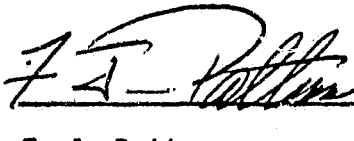
CERTIFICATE OF COMPLIANCE

Specimens supplied on Contract NAS9-15685, Purchase Request No. 8-122-020, have been manufactured and tested to the requirements of applicable Vought Corporation specifications for Reinforced Carbon-Carbon components. Noted specimens comply with these requirements.

Specimens and Serial Numbers

A-305-9 thru 14  
A-307-1 thru 7  
A-308-9 thru 15

A-306-1 thru 6  
A-307-9 thru 14  
A-308-1 thru 6

 17 July 1980

F. J. Patterson  
Quality Program Manager  
Carbon-Carbon Hardware

## QUALITY ASSURANCE REPORT

### NON DESTRUCTIVE EVALUATION

Ultrasonic, radiographic and eddy current thickness tests have been performed on noted specimens and meet applicable specification requirements.

Coating thickness ranges from 0.020 - 0.034"

### TEST RESULTS

Tube Furnace Test (2300°F, 6 hour duration)

<u>Specimen</u>	<u>Mass Loss</u>	<u>Flex Strength</u>
E2	0.045 LBS/FT <sup>2</sup>	9,567 RT PSI
E4	0.037 LBS/FT <sup>2</sup>	13,347 RT PSI
E7	0.021 LBS/FT <sup>2</sup>	15,183 RT PSI
Average	0.034 LBS/FT <sup>2</sup>	12,699 RT PSI



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Post Office Box 225907 • Dallas, Texas 75265

2-19200/OL-582

16 July 1980

To: National Aeronautics and Space Administration  
Lyndon B. Johnson Space Center  
Houston, Texas 77058

Attn: Mr. D. J. Tillian  
Mail Code ES3

Subj: NASA Samples - Contract NAS9-15685

1.0 The contractual requirements of NAS9-15685, Modification 3S, specify the fabrication and delivery of a minimum of 27 and a maximum of 48 test specimens. A total of 38 specimens will be delivered, 18 specimens with TEOS only and 20 specimens with Type A Coating Enhancement.

2.0 The Quality Control log books will contain all of the pertinent process data and the control panel test results for the TEOS specimens. However, the Type A Coating Enhancement was applied to the specimens in the Engineering Test Lab and the formal paperwork for the control panel tests was not prepared for the log book. The current production specification was used and the Type A treated hardware delivered meets all current production specification requirements. The mass loss and flexure test data are included below from the Type A control panel tests:

Specimen	Temp., °F	Time, Hrs.	Mass Loss, PSF	F <sub>bu</sub> , PSI
E5	2300°F	12	-.0003	16,775
E6	1000°F	18	.0662	10,067

G. B. Whisenhunt  
Program Manager - Space Shuttle

DWJ/vng

Manufacturing	_____
Fin. Mgmt.	_____
Dir. Space Pgm.	_____
Config. Mgmt.	_____
LFSS Eng. Proj.	_____
Materials	_____
LESS Quality	_____
Pgm. Control(2)	_____
RFCA Quality	_____
Prog. Mgr.	_____
RFCA Eng. Proj.	_____
PMO File	_____
MCCS(2)	_____
Rockwell Rps.(2)	_____

## SECURITY CLASSIFICATION

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Dallas, Texas 75265

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National Aeronautics & Space Admin.  
Ames Research Center  
Receiving Section 255-3  
Order No. A-7]]25B(LAM)  
Moffett Field Ca. 94035

DATE 8-4-80

NUMBER RFS-RCC-218

YOUR INVOICE	DATED	AMOUNT	REC. REPORT

CHARGE TO

- ☐ RETURNED FOR CREDIT  
☐ RETURNED FOR CREDIT AND REPLACEMENT  
☐ REPAIR OR REWORK AT VENDOR'S EXPENSE  
☐ REPAIR OR REWORK AT OUR EXPENSE  
☐ REPAIR OR REPLACEMENT COVERED BY GUARANTEE  
☒ MISCELLANEOUS (EXPLAIN) Test Samples

INSPECTION REQUIRED: ☐ LTV ☐ GOV'T. ☐ CUST. ☒ NoneMATERIAL CLASS: ☐ HAZARDOUS ☒ NON-HAZARDOUS

REFER TO:	ACCOUNT NO.	DELIVERY DATE DUE 8-6-80	YOUR PO NUMBER A-71125B (LAM)
P. O. N.	VIA U.P.S. Air	B/L NO.	PREPAID COLLECT
REG. REPORT NO.	OUR PO NUMBER	STORES REQ.	GOV'T CONTRACT ORDER NO.
			G. O. NUMBER 3801 DAKS 1001

CONTRACT ITEM NO.	QUANTITY	PART NO.	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
	6	-	RCC Composites; 2.8 inch diameter samples, 19 ply, TEOS treated  S/N's A-306-7, A306-8 A-307-15, A307-16 A-308-7, A308-8		1500
2	4	-	RCC composites; 2.8 inch diameter samples, TEOS treated and coated with Type "A"  S/N's A-306-15, A-306-16 A-307-8, A-308-16		1000

INSPECTION		LAYOUT		PRESERVATION		PACKING		AUTHORIZED IN ACCORDANCE WITH AER. S.P. 441.1			
LTV	CUST	LTV	CUST	LTV	CUST	LTV	CUST	SIGNATURE G. B. Whisenhunt 2-19200 7475			
BOX NO.		TYPE		LGTH	WIDTH	HT.	GROSS WT.	NAME (TYPE) UNIT EXT.			
								FOR SHIPPING USE ONLY			
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REQUEST FOR SHIPMENT

0-87574 R2

ENCLOSURE 4

CONTENTS:

- o DESIGN INFORMATION RELEASE DIR 2-53200/RCC/2-0008

DESIGN INFORMATION ~~SECRET~~ - RELEASE 9-82042 R3ORIGINAL PAGE IS  
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MODEL(S) AND EFF.

DIR. NO.

REV.

NASA-LaRC Radiant Mass Loss Test Data

2-53200/RCC/2-0008

WBS OR DD NUMBER

SYSTEM LESS		REF. G.O. NUMBER 3804 EARE 1001		DATE 28 October 1982		PAGE 1		OF 19			
FILL IN BLOCK BELOW FOR INFORMATION REQUEST				FILL IN BLOCK BELOW FOR INFORMATION RELEASE							
TO:		GROUP		IN REPLY TO DIR. NUMBER							
R/Q BY		GROUP		REL. TO D. W. Johnson				GROUP 2-32040			
REASON:				PREPARED BY C. N. Webster		DATE 10/29/82		CHECKED BY C. B. May		DATE 10-29-82	
<input type="checkbox"/> VAC ONLY <input type="checkbox"/> NASC <input type="checkbox"/> NPRO <input type="checkbox"/>				GROUP APP. <i>[Signature]</i>		DATE 11/2/82		PROJ OFFICE <i>[Signature]</i>		DATE 11/2/82	
CC											

M. Green, G. B. Whisenhunt, W. W. Rhoades, R. O. Scott, C. L. Hoffman, Dr. D. M. Rummeler-  
NASA-LaRC; Rockwell International (4), D. M. Shuford

M0991B



## 1.0 BACKGROUND

NASA-JSC contract NAS9-15685 with Vought Corporation was originally for the delivery of 48 reinforced carbon-carbon (RCC) test samples and the mechanical testing of 18 existing combined-environment tension specimens. The 48 specimens were for mass loss characteristic tests performed at NASA-LaRC under the direction of Dr. Donald M. Rummler. The basic contract has been modified several times to include application of Type A sealant to 18 of the 48 specimens, and more recently to fabricate advanced carbon-carbon (ACC) specimens.

This DIR deals only with a portion of this contract: the mass loss testing accomplished by NASA-LaRC on the majority of the 48 RCC test specimens.

## 2.0 SPECIMENS

The 48 RCC samples were rectangles (1.7" x 6.7") 19-ply thick. All were processed through the RCC densification steps, silicon carbide coated and TEOS impregnated (RCC/Coated/TEOS). Eighteen of the 48 specimens were later returned to Vought for incorporation of the Type A surface enhancement. These 18 specimens can be designated RCC/Coated/TEOS/Type A.

In terms of surface porosity, all 48 specimens tend toward being non-porous.

## 3.0 TEST CONDITIONS

Mass loss testing was accomplished in NASA-LaRC's multiple-parameter facility. Some mass loss conditioning was done at steady state conditions, that is, constant temperature and pressure. Other specimens were exposed to cyclical variations in temperature and pressure.

Three cyclic profiles were used. One with a peak temperature greater than 1000°F; one with a peak temperature greater than 1300°F; one with a peak temperature greater than 1600°F. These profiles were taken from the thermal analysis of the Shuttle wing 55% half span for the 14414.1C trajectory.

Nine separate steady state conditions were used: 0.1, 0.3 and 1.0 atmospheres pressure at temperatures of 1200°F, 1400°F and 1600°F.

In LaRC's multiple-parameter facility, two test specimens and a control specimen are exposed simultaneously. The control specimen is instrumented with thermocouple(s) for temperature measurement.

#### 4.0 TEST RESULTS

NASA-LaRC furnished the mass loss data to Vought. These results are presented herein. The data taken during the cyclic exposure are presented in Figures 1 through 6. Figures 1 and 2 are the data taken during 100 cycles with a peak temperature of 1644°F. Figures 3 and 4 are the data taken over 100 cycles with a peak temperature of 1367°F. Figures 5 and 6 present the data taken during 100 cycles with a peak temperature of 1088°F. On each figure the data for one RCC/Coated/TEOS specimen and one RCC/Coated/TEOS/Type A specimen is plotted. Also plotted is the predicted mass loss based on Vought's mass loss correlation for RCC/Coated/TEOS material and measured temperatures and pressures.

Data taken at steady state conditions are presented in Figures 7 through 15. Again both TEOS and Type A specimens are shown with the correlation for TEOS treated material. Two Type A treated specimens are shown at 1400°F, 0.3 atmosphere and at 1600°F, 0.3 atmosphere.

#### 5.0 DISCUSSION

The February 1978 correlation prediction plotted on each figure is based on RCC/Coated/TEOS material and should only be compared directly with the TEOS specimens. The TEOS specimen data are shown as circles on each figure. Looking first at the steady state data, there is good agreement between the TEOS specimen and the prediction at 1200°F, all pressures. At 1400°F there is good agreement at 0.3 atmosphere, but the prediction over predicts the mass loss of these individual specimens at 0.1 atmosphere and 1.0 atmosphere. At 1600°F there is good agreement at all pressures.

The mass loss of the Type A treated specimens is well below that of the non-Type A specimens at all temperatures and pressures.

In Figures 1 and 2 the correlation prediction under predicts the measured mass loss of the TEOS treated specimens exposed to the 1644°F peak temperature profile. The correlation is suspected to be in error at 1600°F because there was no 1600°F data used in the determination of the correlation constants. This is in the transition region between the rate controlled mass loss regime and the diffusion limited regime.

For the 1367°F peak temperature profile the February 1978 correlation again under predicts the measured mass loss, but not as much as at the higher temperature profile. The prediction catches up at about 95 cycles.

For the low-temperature profile (1088°F max), the prediction correlation over predicts the mass loss of specimen 13HP35 (Figure 5) and matches fairly well with the measured mass loss of specimen 10HP28 (Figure 6). This shows the scatter in the RCC/Coated/TEOS mass loss data.

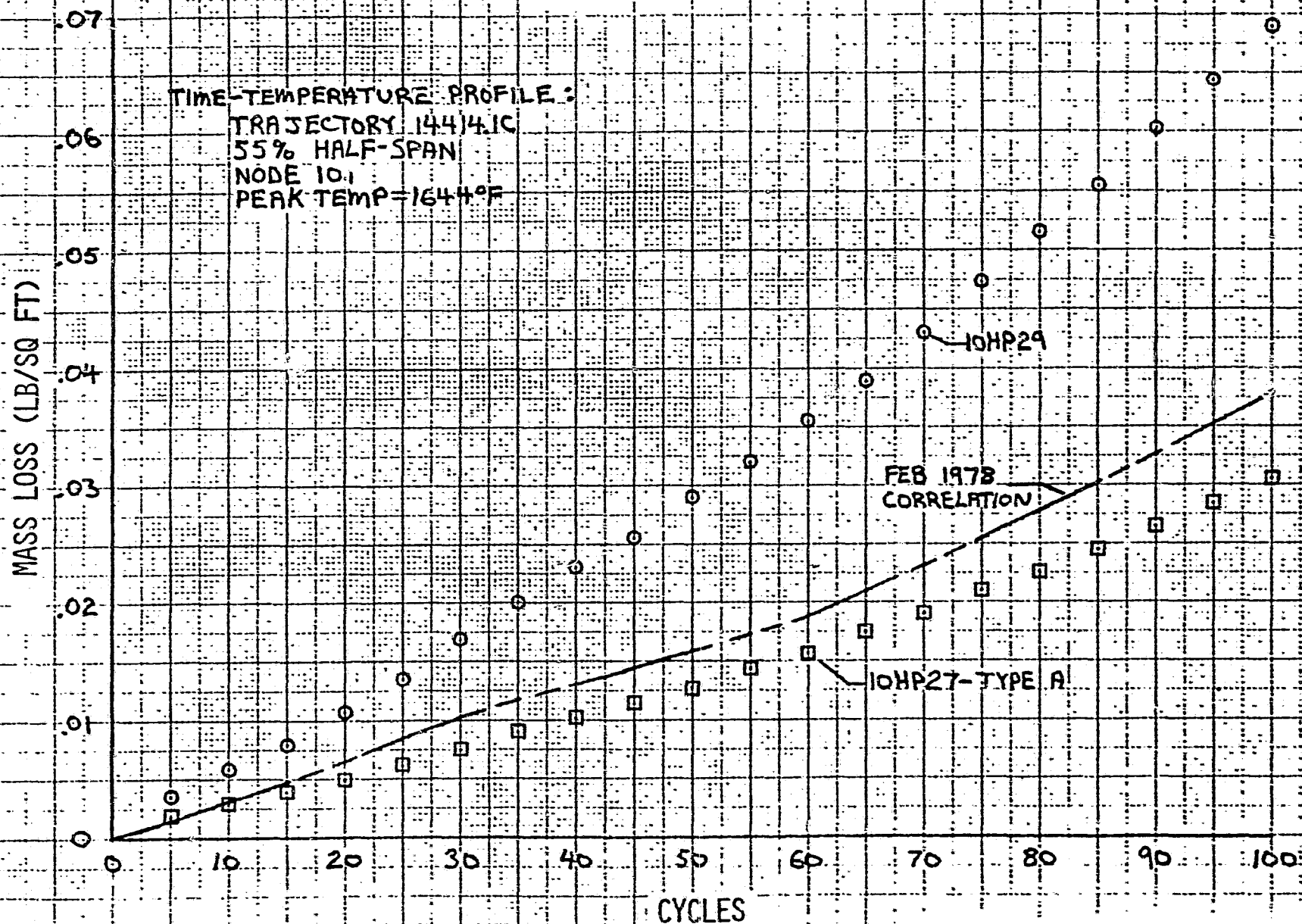
NASA-LaRC made the following observations based on their examination of the specimens and data:

1. The Type A enhanced specimens are superior (lower mass loss) to the RCC/Coated/TEOS specimens in every case.
2. One Type A enhanced specimen did not exceed 0.10 pounds per square foot mass loss after 100 cycles to the most severe environment in the test series (1088°F peak temperature cycle).
3. The RCC/Coated/TEOS material maintained its integrity even after exceeding mass loss guide lines.
4. The data scatter appears to be less for the Type A enhanced specimens than for the RCC/Coated/TEOS material.

CLEARPRINT CHART

FIGURE 1

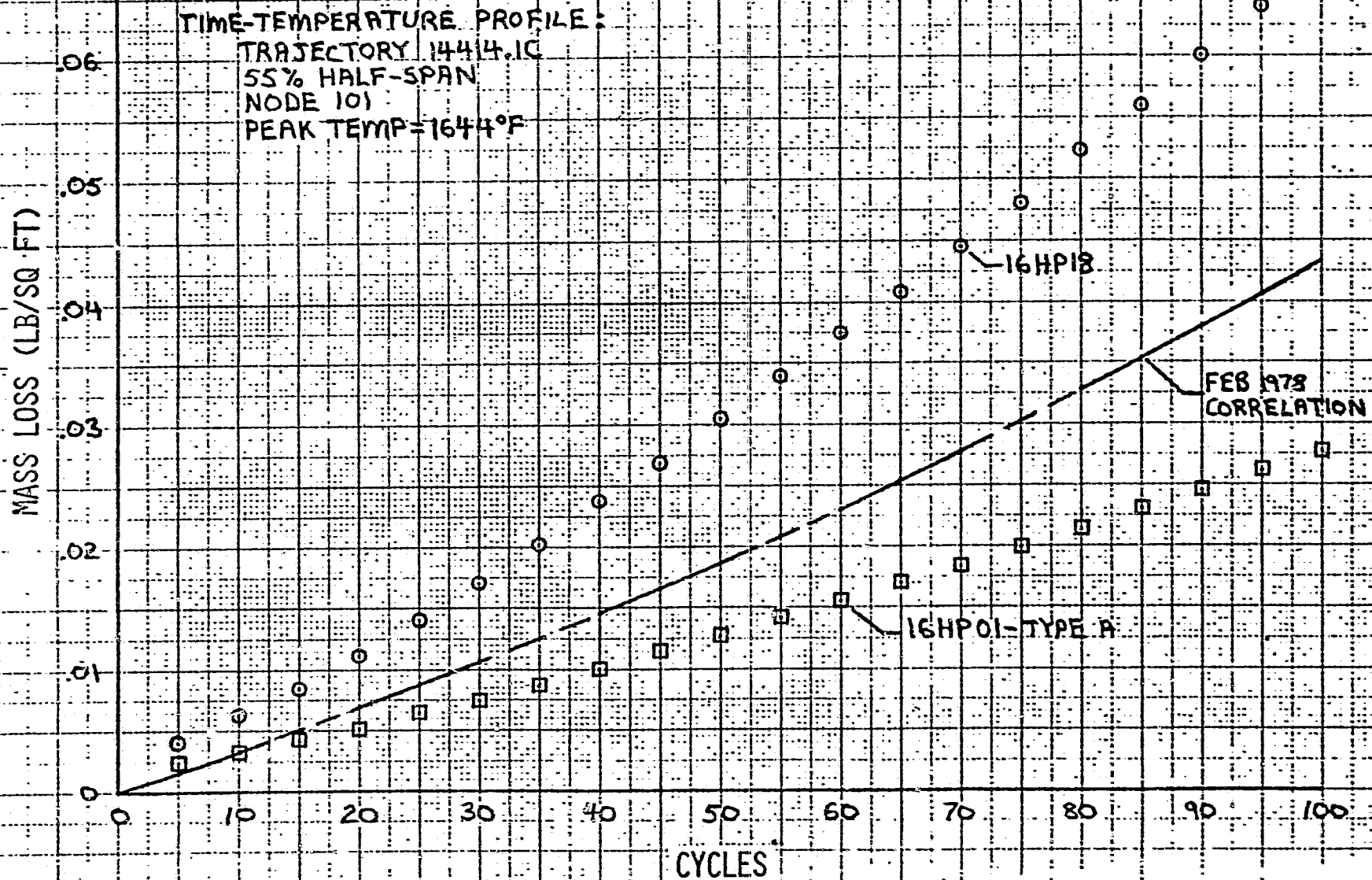
NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A



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CLEARPRINT CHART

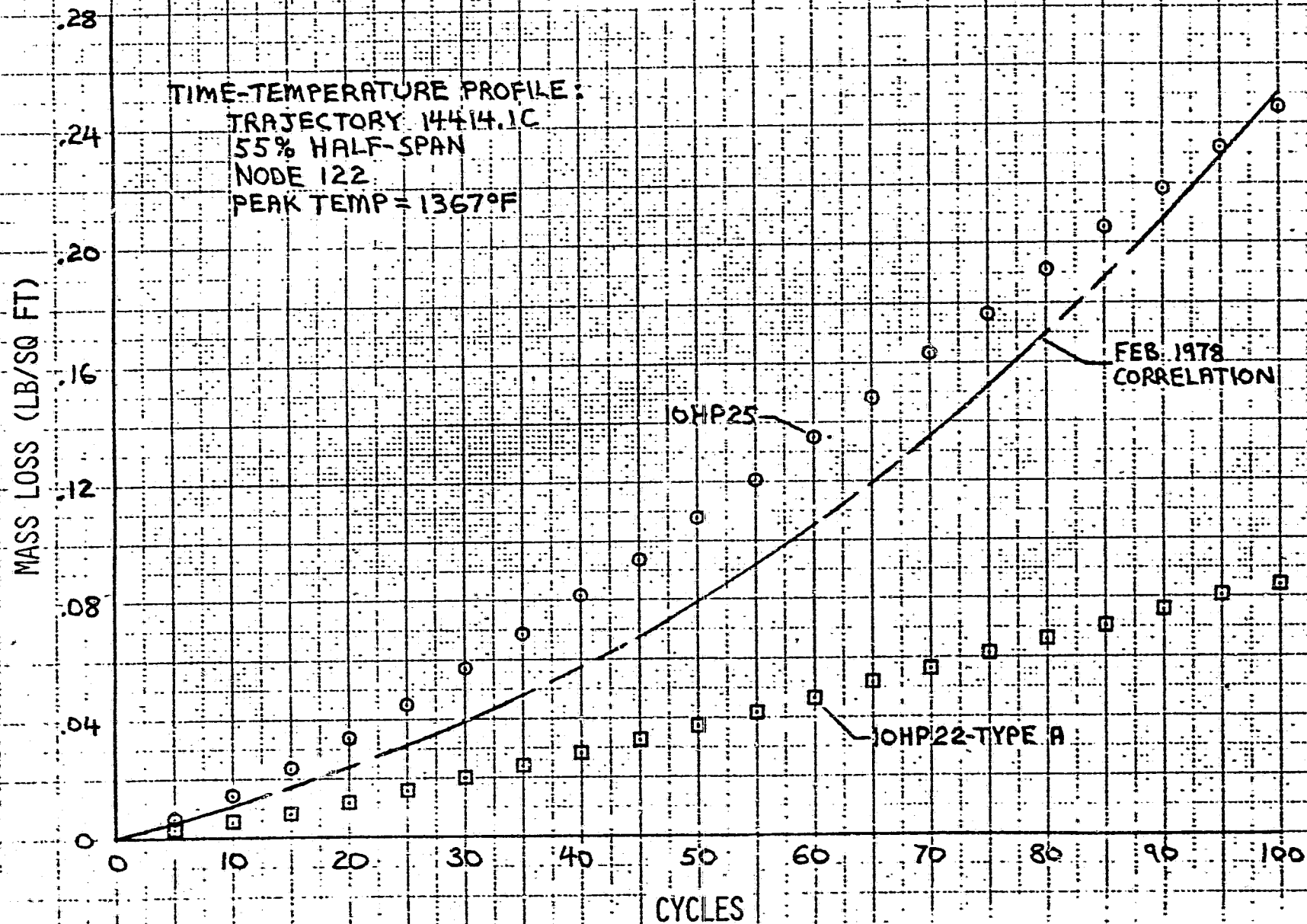
FIGURE 2  
NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A



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FIGURE 3

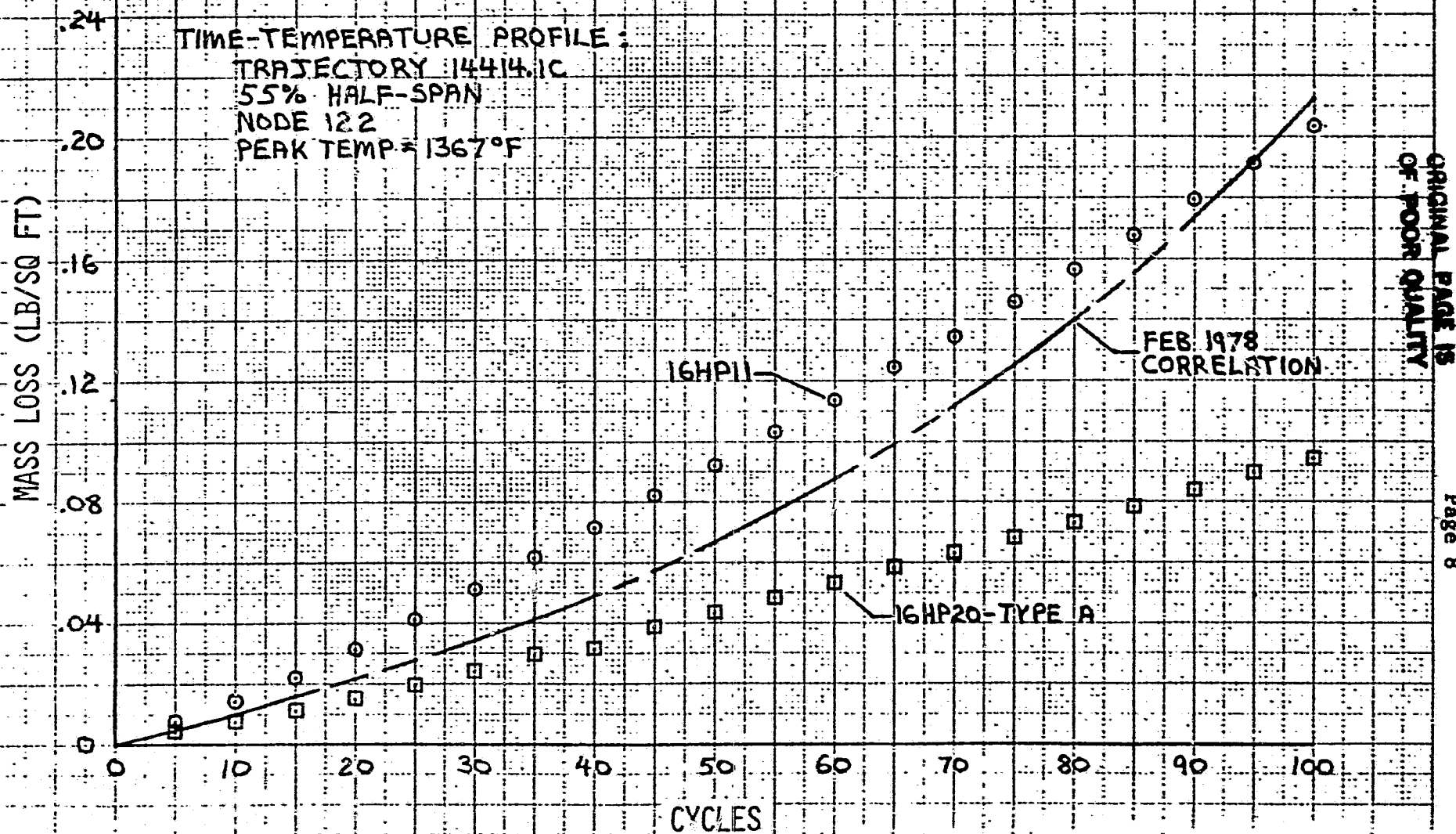
NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A



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FIGURE 4

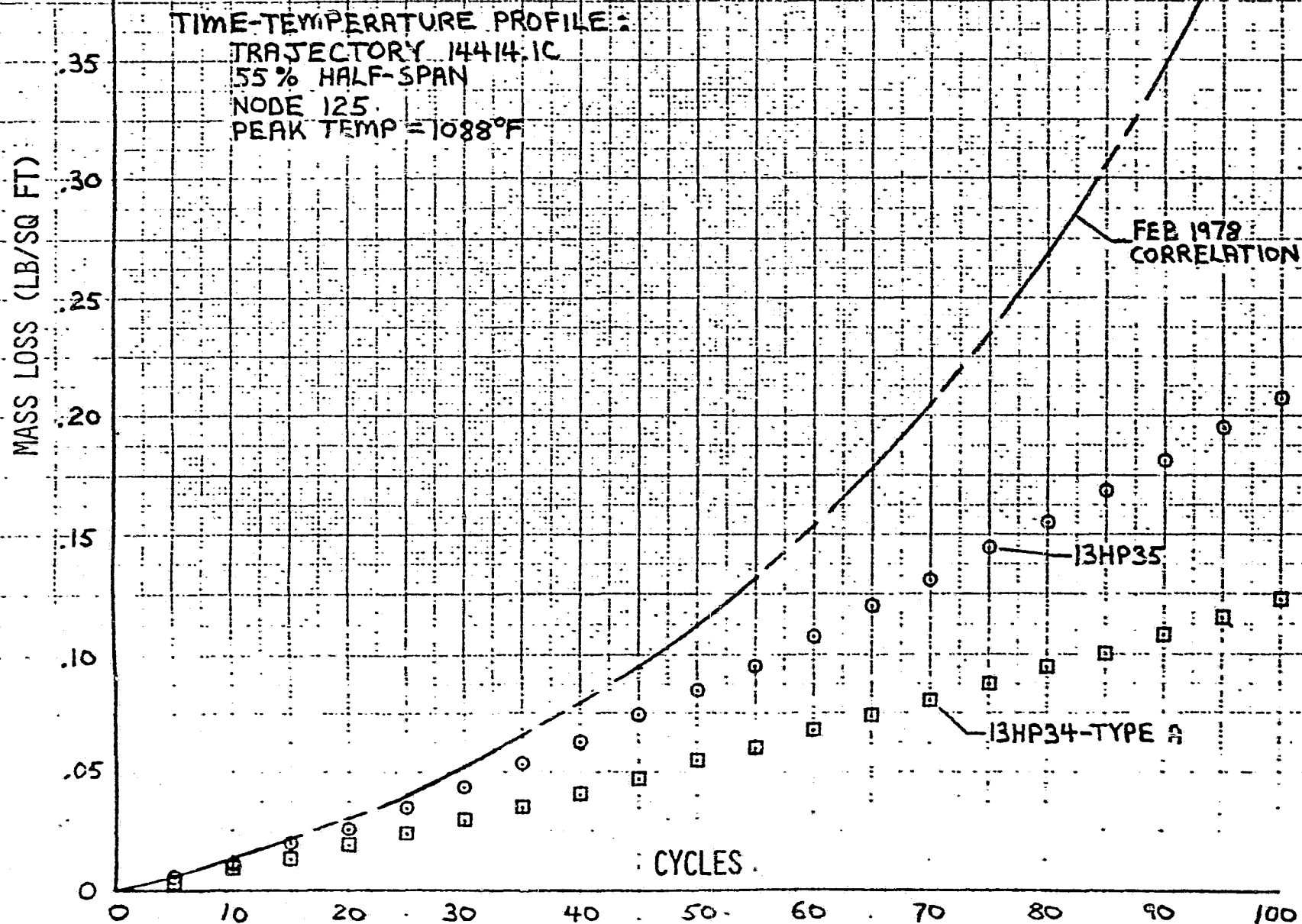
NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A



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FIGURE 5

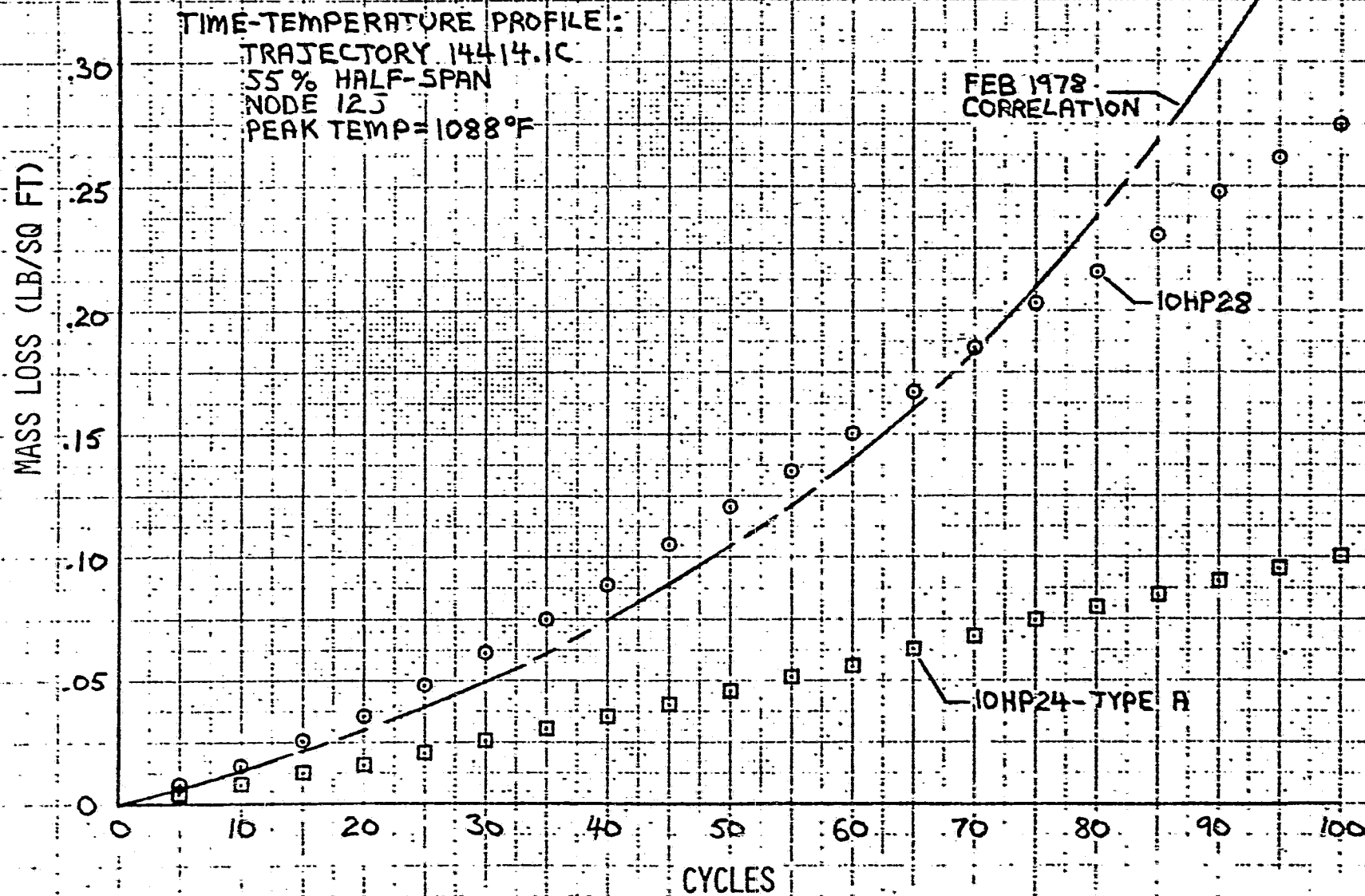
NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A



CLEARPRINT PAPER

FIGURE 6

NASA-LARC RADIANT ENTRY CYCLE MASS LOSS  
RCC/COATED/TEOS AND TYPE A

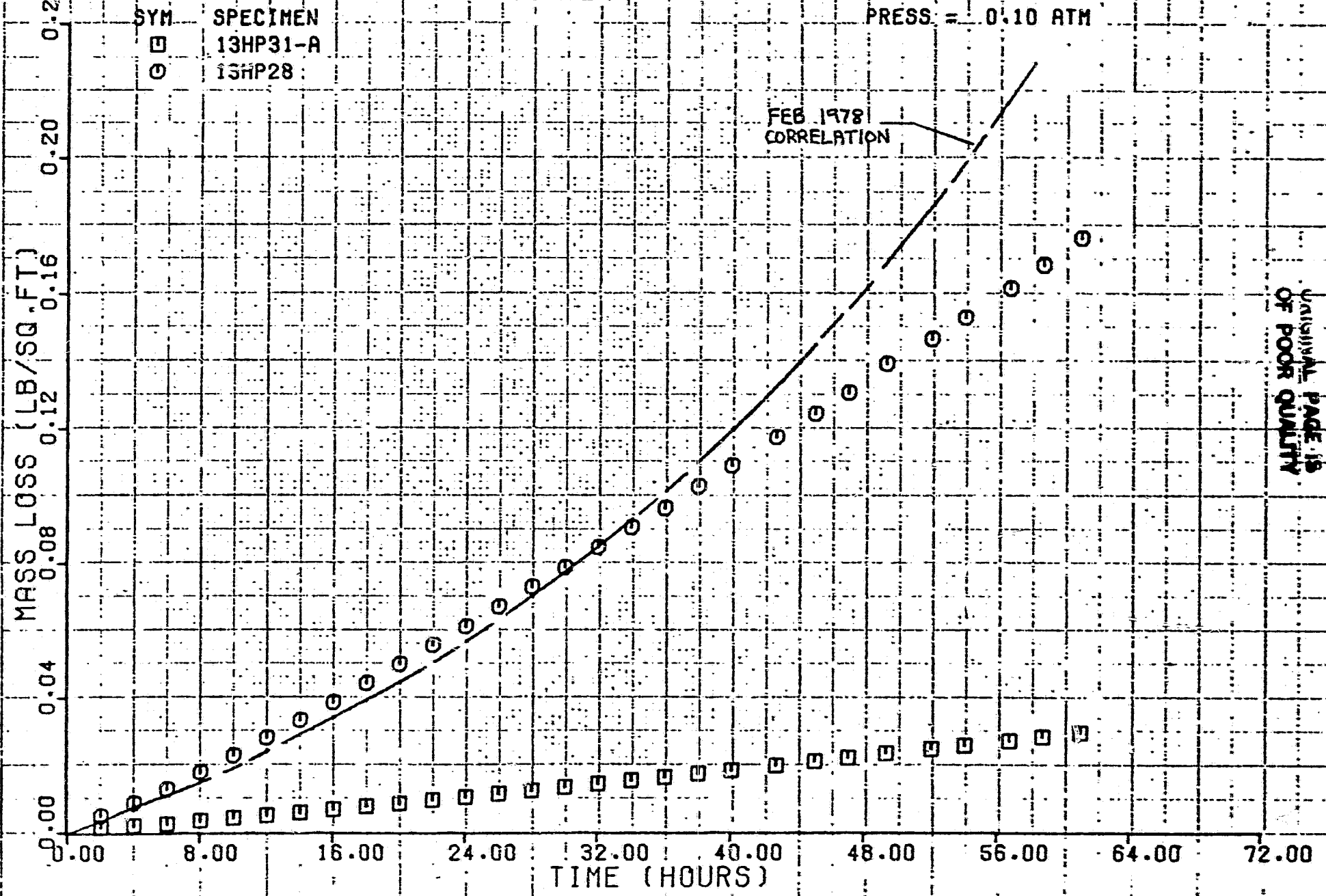


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# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 7

TEMP = 1200. DEG F  
PRESS = 0.10 ATM



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# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 8

TEMP = 1200. DEG F  
PRESS = 0.30 ATM

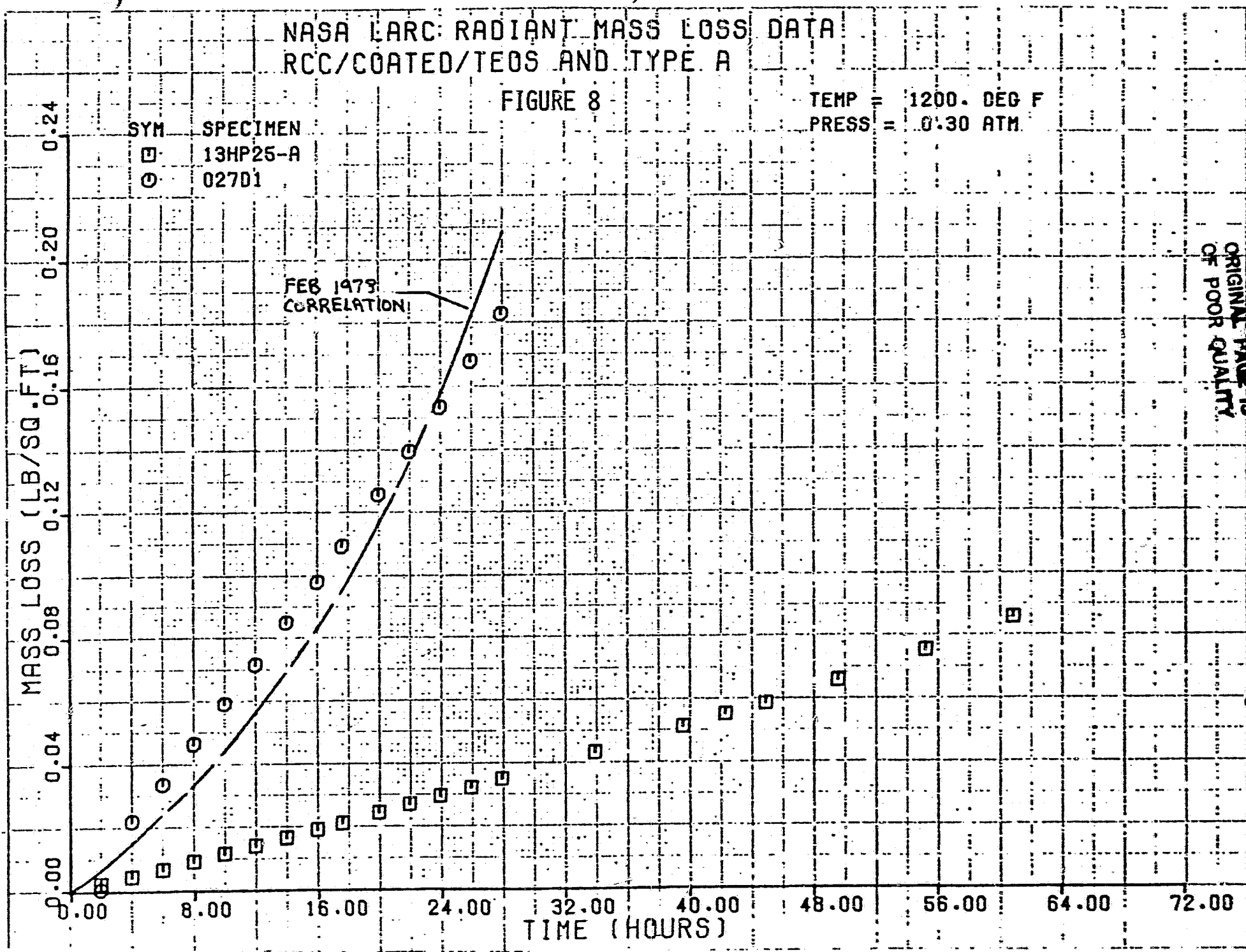
SYM SPECIMEN  
□ 13HP25-A  
○ 027D1

MASS LOSS (LB/SQ.FT)

FEB 1975  
CORRELATION

TIME (HOURS)

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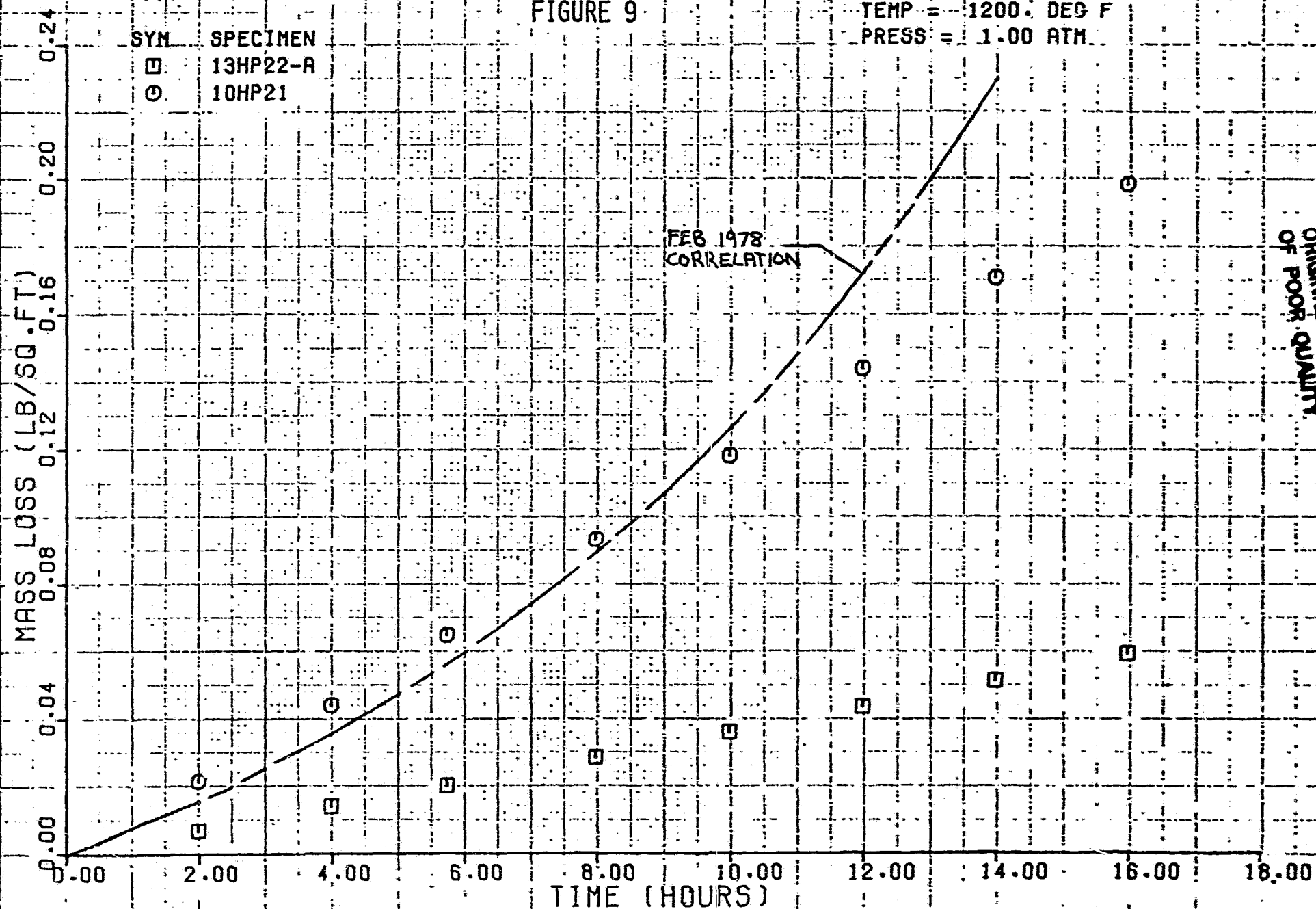


# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 9

TEMP = 1200. DEG F  
PRESS = 1.00 ATM

SYN SPECIMEN  
□ 13HP22-A  
○ 10HP21



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# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 10

TEMP = 1400. DEG F  
PRESS = 0.10 ATM

SYN SPECIMEN  
□ 16HP13-A  
○ 16HPD6

MASS LOSS (LB/SQ.FT.)

FEB 1978  
CORRELATION

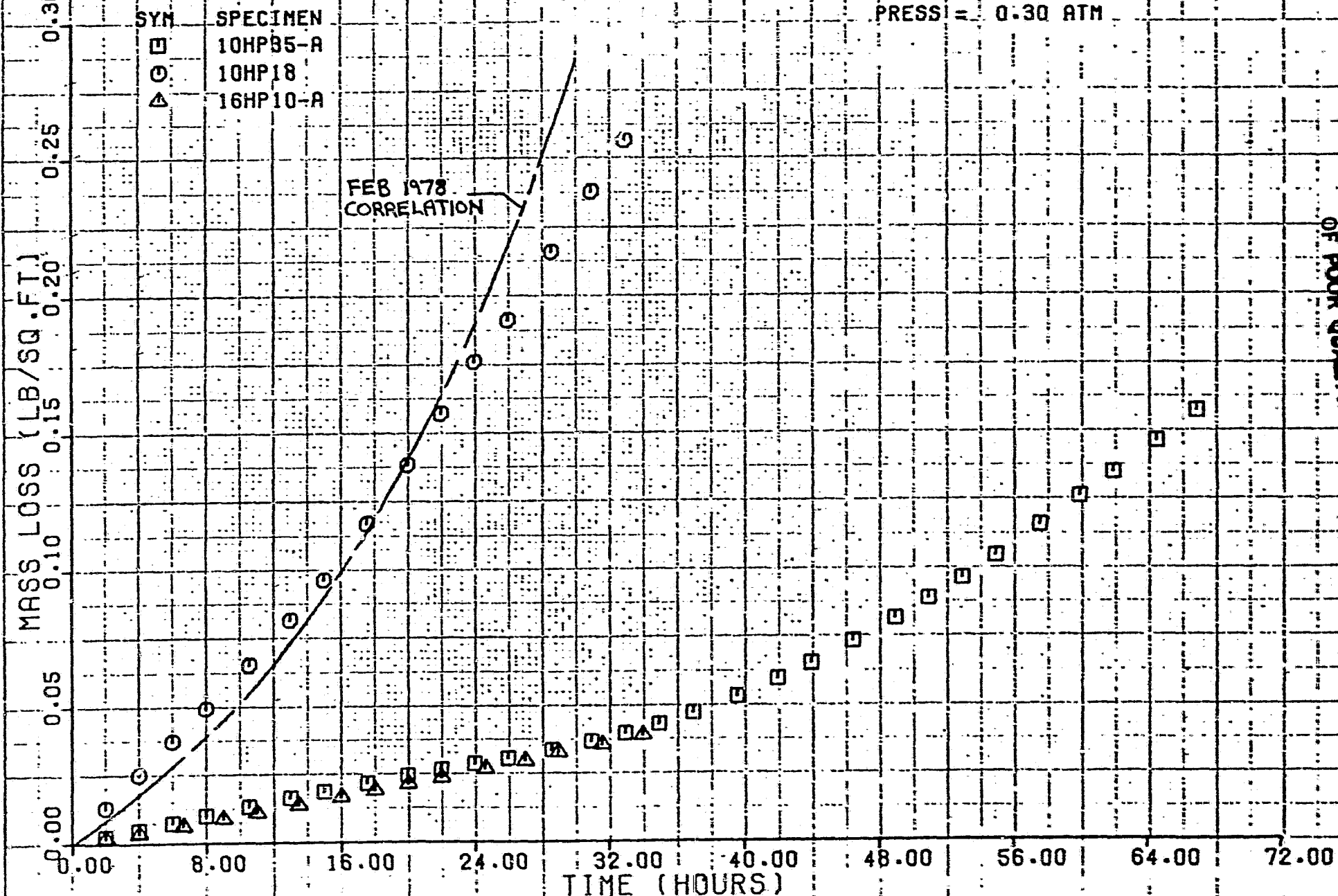
PAGE 15  
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TIME (HOURS)

# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 11

TEMP = 1400. DEG F  
PRESS = 0.30 ATM



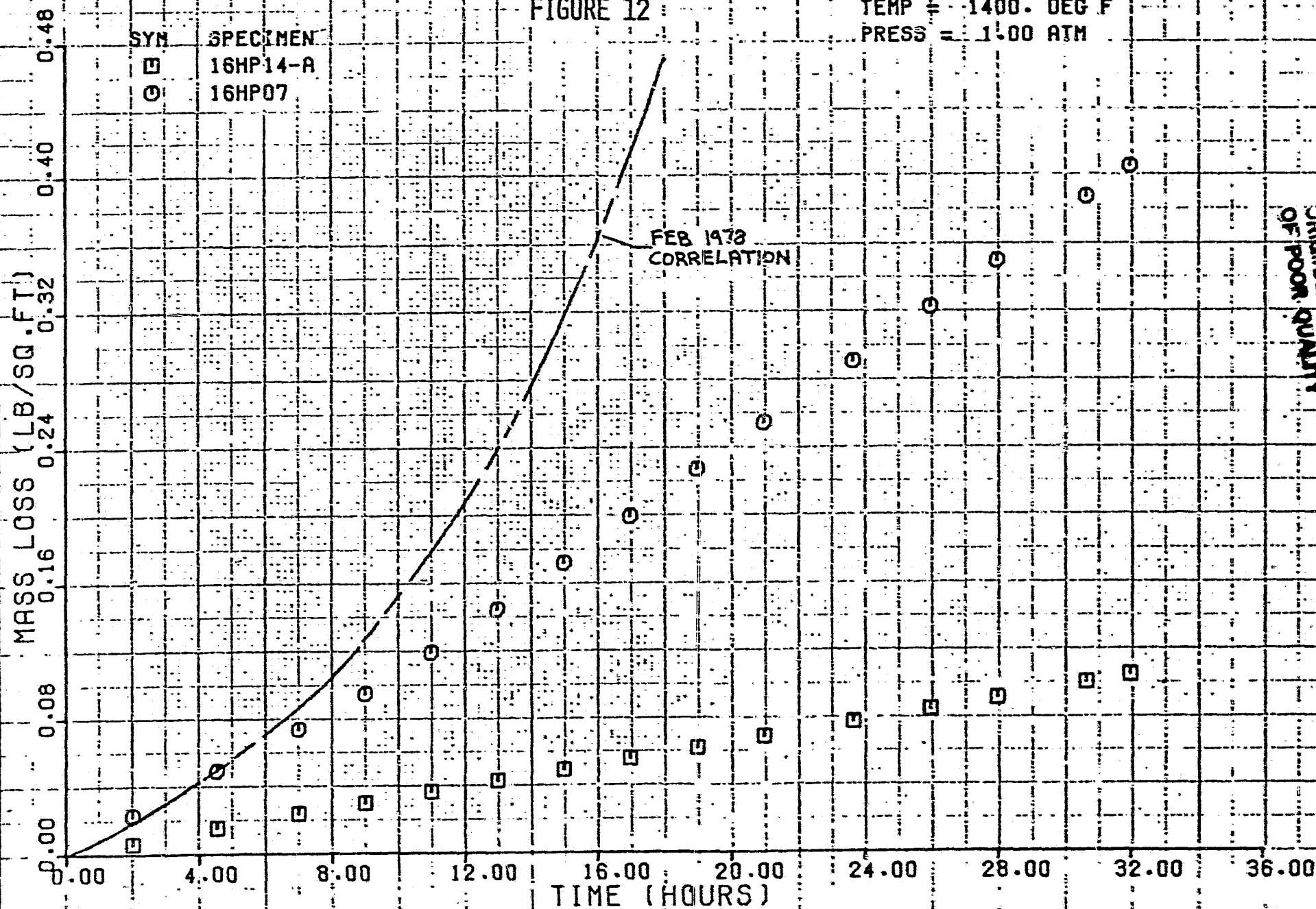
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# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 12

TEMP = 1400. DEG F  
PRESS = 1.00 ATM

SYN SPECIMEN  
□ 16HP14-A  
○ 16HP07



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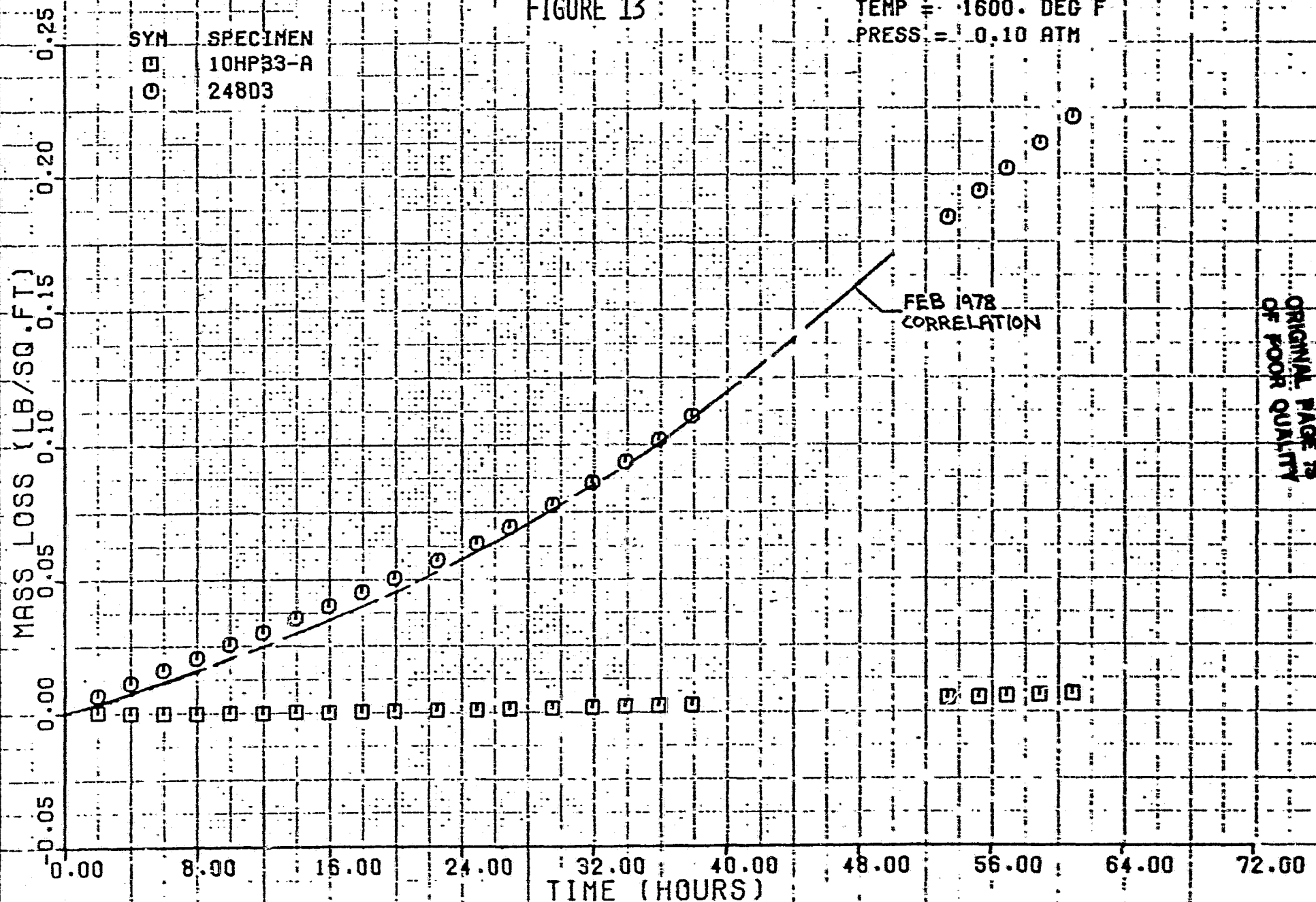


# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 13

TEMP = 1600. DEG F  
PRESS = 0.10 ATM

SYN SPECIMEN  
□ 10HP33-A  
○ 24803



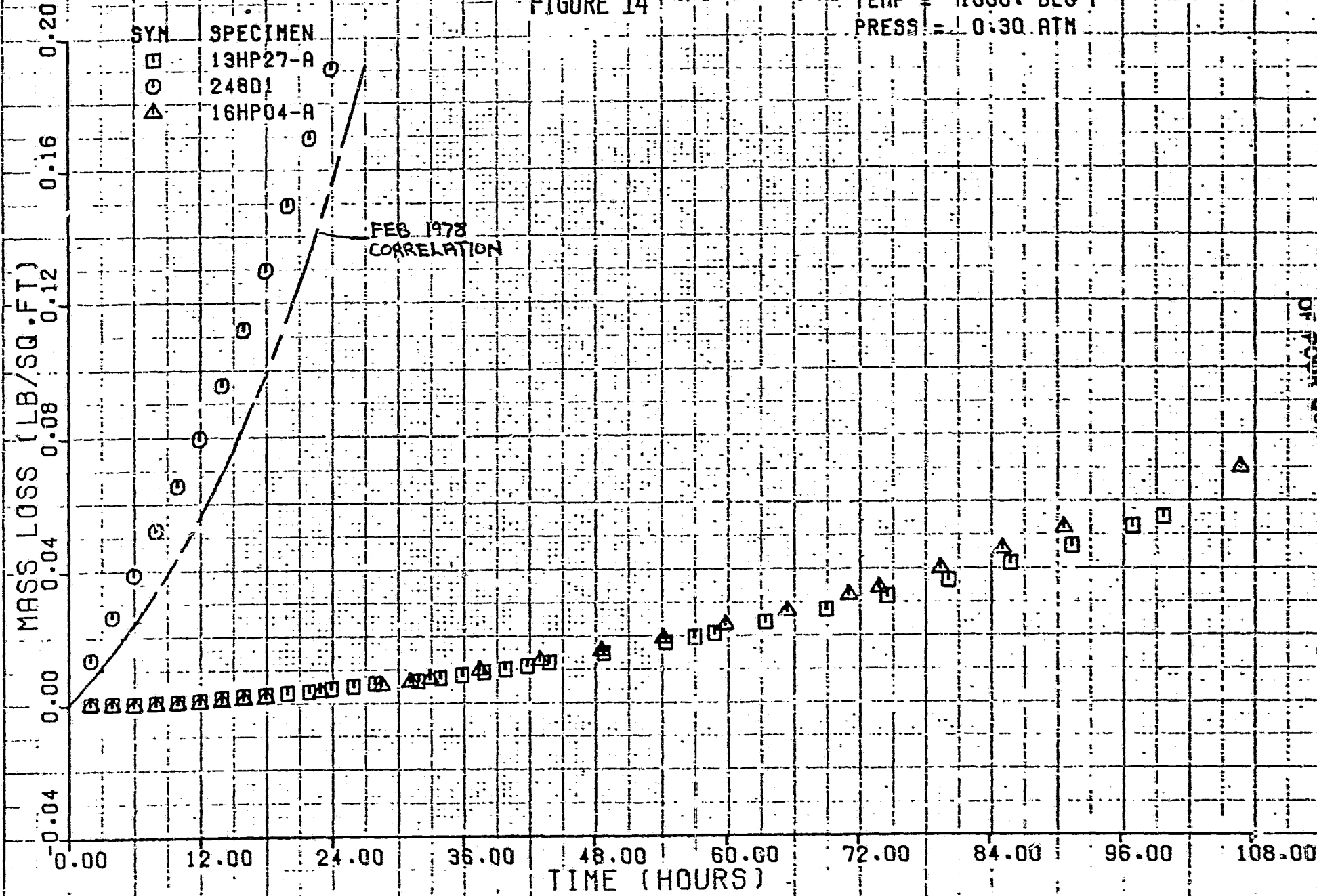
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# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 14

TEMP = 1600. DEG F  
PRESS = 0.30 ATM



ORIGINAL PAGE 18  
OF FOUR QUALITY

# NASA LARC RADIANT MASS LOSS DATA RCC/COATED/TEOS AND TYPE A

FIGURE 15

TEMP = 1600. DEG F  
PRESS = 1.00 ATM

